Applied Biological Research 24(1): 115-118; (2022)
DOI: 10.5958/0974-4517.2022.00013.1

SHORT NOTE

DIFFERENTIAL SUSCEPTIBILITY OF *Popillia cupricollis* (COLEOPTERA: SCARABAEIDAE: RUTELINAE) TO DIFFERENT GROUPS OF INSECTICIDES

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(Received 19 September, 2021; accepted 4 January, 2022)

Scarabaeidae is the 2nd largest family within the Order Coleoptera and worldwide has about 30,000 species with 13 subfamilies, of which Melolonthinae and Rutelinae are the largest cosmopolitan subfamilies (Khanal *et al*., 2012). The family Scarabaeidae is represented by 2,500 species in India (Pathania *et al.*, 2015). Most species in sub-family Melolonthinae and Rutelinae are destructive and notorious insect pests. Both adult and larva are pestiferous and cause severe damage to the field-, fruit- and tree-crops, and grasslands. In India, larvae of the scarab beetles have been identified as one of the five national pests (Sharma, 2002). The scarab larvae cause an estimated reduction of 40-80% in crop yield (Gite *et al*., 2015). In India, the North-Western Himalayan region comprising of the states of Uttarakhand, Himachal Pradesh and Jammu & Kashmir has been identified as hot spot for white grub diversity (Subbanna *et al.*, 2020). In this region, maximum cropped area is under well-drained sandy soil along the hill slopes which favours the growth and development of white grubs. The varied altitude, steepness, microclimate, and availability of food for both adults and larvae in Uttarakhand make it favourable for scarab diversity. Numerous practices such as physical, behavioural, biological, chemical, cultural, mechanical, and integrated methods have been adopted for white grub management (Paschapur *et al*., 2017). Of these, chemical control is considered as the first line defense against these species under pest outbreak conditions, as they emerge in large numbers and get concentrated on host trees for feeding and mating. Therefore, the selection of most efficient insecticide for timely and effective management is essential to minimize the number of adults and grub populations under field conditions. The shiny chafer beetle, *Popillia cupricollis*, is diurnal in nature and no synthetic attractant is available or reported to lure and trap this beetle. It is difficult to manage it by using cultural (light trap) and behavioural (pheromone trap) tactics. The chemical control is the only available strategy used to manage *P. cupricollis* population in field during pest outbreak. But, species-specific information regarding the insecticidal management of *P. cupricollis* is not available. So, the present study was aimed to generate information on the *in vitro* susceptibility of *P. cupricollis* to 21 insecticides belonging to different chemical groups.

The laboratory bioassays were conducted to assess the efficacy of 21 commonly used insecticides (Table 1) against adult populations of *P. cupricollis*. The experiments were conducted in the Entomology Laboratory, ICAR-VPKAS (Vivekananda Parvatiya Krishi Anusandhana Sansthan), Experimental Farm, Hawalbagh (29.63°N and 79.63°E, 1250 m amsl), Uttrakhand in October 2020. The diurnal chafer beetles were hand-picked from maize and finger millet crops between 12:00 to 15:00 h, transferred to the sterile 5 L plastic containers containing fresh finger millet shoots and transported to the laboratory. In laboratory, they were kept in mesh cages with a bucket of autoclaved soil and FYM mixture (1:1), and the freshly cut shoots of finger millet were given as food. After 24 h, the actively moving shiny chafer beetles were used for laboratory bioassays. The bioassay procedure recommended by Stanley and Preetha (2016) was followed to assess the contact toxicity of selected insecticides. A 9 cm dia. filter paper (Whatman No. 1) was impregnated with 1 mL solution of test concentration of insecticide in a Petri-plate and air-dried for 30 min. Ten adults were released in each Petri-plate. The experiment was replicated three times. After 4 h of contact, the adults were transferred to a fresh netted insect rearing box (9 cm dia x 5 cm high) with fresh host leaves. A control treatment ((water only) was also set up to obtain corrected mortality. The data on adult mortality was recorded after every 24 and 48 h after treatment (HAT) by counting the dead adults in each treatment and the data obtained was transformed to percent mortality.

In present study, 21 insecticides (from both conventional and novel groups) were evaluated against the adults of *Popillia cupricollis* under laboratory conditions. Substantial variations in susceptibility to the tested insecticides was noticed with mortality ranging from 0 to 100%. Among the tested insecticides, chlorpyriphos 20% EC, dichlorvos 76% EC and malathion 50% EC yielded the highest percent mortality of 98.33 ± 1.67, 100.00 ± 0.00, and 96.11 ± 2.04, respectively, 48 HAT (Table 1). The other insecticides did not cause any substantial mortality in adult beetles, except deltamethrin 2.8% EC, which reported 35.00 ± 2.89% mortality 48 HAT. The relatively low mortality observed may be attributed to many factors including insufficient dose of insecticide, difference in the mode of action, and insufficient time for mortality to become apparent. But, to our knowledge, there is no study addressing foliar spray of insecticide against the adult scarab beetles, so it is difficult to relate our results to similar studies. However, insecticides like azadirachtin 0.15% EC, buprofezin 25% SC, chlorantraniliprole 18.5% SC, cypermethrin 25% EC, and flubendiamide 39.35% showed no adult mortality, thus revealing their inefficacy in managing the *P. cupricollis* population. Several authors reported substantial variation in susceptibility of scarab beetles to different groups and concentration of insecticides (Cowles and Villani, 1996; Gilbert and Gill, 2010). The lethal effects of several insecticides and their effectiveness in controlling specific scarab beetle species have been studied and thiamethoxam is reported as a potent insecticide against *Heteronychus arator* (Silva and Boss, 2002), fipronil against *Diloboderus abderus* larvae (Drinkwater, 2003), lambda-cyhalothrin and thiacloprid against *P. japonica* larvae and adult (Baumler and Potter, 2007), chlorpyrifos,

Table 1: *In vitro* evaluation of insecticides against adults of *Popillia cupricollis*

Common name/ formulation	Chemical group	Trade name	Dose used	Bioassay 24 h	Bioassay 48 h
Acephate 75% SP	Organophosphates	Acemain	1.6 g L^{-1}	6.67 ± 1.67	11.67 ± 1.67
Acetamiprid 20 % SP	Chlornicotinyl group	Nagarjunaennova	0.3 g L^{-1}	5.67 ± 3.33	6.11 ± 2.04
Azadirachtin 0.15% EC	Botanical	Vanguard	6.0 mL L^{-1}	0	0
Buprofezin 25% SC	Thiadiazinone	Tata applaud	2.0 mL L^{-1}	0	0
Cartap hydrochloride 50% SP	Nereis toxin	Dartiz	1.0 g L^{-1}	3.33 ± 3.33	7.78 ± 2.22
Chlorantraniliprole 18.5% SC	Diamide group	Coragen	0.3 mL L^{-1}	0	0
Chlorfenapyr 10% SC	Pyrroles	Intrepid	0.3 mL L^{-1}	0	13.33 ± 1.67
Chlorpyriphos 20% EC	Organophosphates	Chlorguard	2.0 mL L^{-1}	96.67 ± 3.33	98.33 ± 1.67
Cyantraniliprole 10.26% OD	Diamide group	DuPont benevia	1.0 mL L^{-1}	0	7.78±2.23
Cypermethrin 25% EC	Synthetic pyrethroid	Challenger	0.5 mL L^{-1}	0	0
Deltamethrin 2.8% EC	Synthetic pyrethroid	Decis	1.0 mL L^{-1}	11.67 ± 1.67	35.00 ± 2.89
Dichlorvos 76% EC	Organophosphates	Nuvan	1.0 mL L^{-1}	98.33 ± 1.67	100.00 ± 0.00
Emamectin benzoate 5% SG	Avermectin	Rilon	0.4 g L^{-1}	7.78 ± 2.22	14.44 ± 0.58
Fipronil 5% SC	Phenylpyrazole	Regent	0.3 mL L^{-1}	0	6.11 ± 2.04
Flubendiamide 39.35% SC	Diamide group	Fame	0.3 mL L^{-1}	0	0
Imidacloprid 17.8% SL	Chlornicotinyl group	Maharaja	0.3 mL L^{-1}	7.78 ± 2.22	13.89 ± 3.89
Indoxacarb 14.5% SC	Oxadiazine	King Doxa	1.0 mL L^{-1}	3.33 ± 1.67	18.33 ± 4.41
Lambda-cyhalothrin 5% EC	Synthetic pyrethroid	Deva Shakti	1.0 mL L^{-1}	6.67 ± 3.33	9.11 ± 2.04
Malathion 50% EC	Organophosphates	Tusk	2.0 mL L^{-1}	77.22 ± 1.47	96.11 ± 2.04
Metasystox 25% EC	Organophosphates	UPL	1.0 mL L^{-1}	0	9.44 ± 3.38
Spinosad 45% SC	Spinosyn	Conserve	0.5 mL L^{-1}	9.44 ± 3.38	7.78 ± 2.23
Untreated control	Water	-	-	0	1.67 ± 1.67
			SE (m)	2.28	1.665
			CV (%)	23.55	13.73
			F-value	177.95	375.48
			P-value	0.000012	0.000003

fipronil and thiamethoxam against *Liogenys fuscus* larvae (Santos *et al.*, 2008), chlorpyriphos, clothianidin and imidacloprid against *Lepidiota mansueta* larvae (Bhattacharyya *et al.*, 2017) and clothianidin and chlorpyriphos against *Holotrichia consanguinea* (Patel *et al.*, 2018). The present study established that chlorpyriphos 20% EC @ 2 mL L^{-1}, dichlorvos 76% EC @ 1 mL L^{-1}, and malathion 50% EC @ 2 mL L^{-1} are highly efficient in suppressing the infestation of *P. cupricollis* and the results are in close concurrence with Patial and Bhagat (2005), Zaki *et al*. (2006), Rahama *et al.* (2014) and Ahad *et al*. (2020) who reported that chlorpyriphos as the best insecticide for management of white grubs. Although several management practices like biological, behavioral, mechanical, physical, and cultural are devised and recommended for white grub management, the diurnal habit of *P. cupricollis* and non-availability of synthetic attractant render the management of *P. cupricollis* outbreaks in Indian Himalayas very cumbersome.

The support and guidance provided by the Director, ICAR-VPKAS, Almora (India) for undertaking this study is gratefully acknowledged. This work was financially supported by All India Network Project on White Grubs and Soil Arthropod Pests, Indian Council of Agriculture Research, New Delhi (India). The authors declare that they have no conflict of interest.

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